2006

Rethinking science education through rethinking schooling

Jim Davies
Australian Science and Mathematics School

Re-thinking science education through re-thinking schooling

Jim Davies

Australian Science and Mathematics School

Jim Davies is currently Principal of the Australian Science and Mathematics School, a public school established in partnership with Flinders University in South Australia. Associate Professor Davies has previously held leadership positions within the education system in South Australia including District Superintendent, Principal and Superintendent leading the introduction of local school management throughout the public education system in South Australia.

Prior to his career in educational leadership and administration, Jim taught agricultural science, science and health education and was the program leader at Urrbrae Agricultural High School, a special focus school in Adelaide. His current professional interests are in the areas of educational innovation, science education, re-configuration of the professional work of teachers, new designs for schooling and alternative modes of learning.

Jim's work is not confined to the Australian Science and Mathematics School. He is currently chair of the South Australian Department of Education's 'Science & Mathematics Futures Innovations Committee', a board member of The Investigator Science & Technology Centre. He is also chair of the Veterans' Children's Education Board for SA and NT.

Abstract

The Australian Science and Mathematics School was designed explicitly to support a renaissance in the teaching of science and to improve the engagement of students in the disciplines of science through highly engaging authentic learning opportunities. The school has adopted an action research approach as a means of re-thinking the elements of schooling and of its science programs. Its working premise is that quality science education is embedded in quality schooling. Science is learned through an innovative interdisciplinary curriculum with a pedagogy aligned to the inquiry methodologies associated with deep engagement in scientific endeavour. The architecturally designed school has transformed the traditional, stereotypical roles of teachers and learners. A strategic partnership with Flinders University has been pivotal in promoting leading edge, emergent sciences in the curriculum and providing professional learning opportunities for staff. The school is now in its fourth year of operation and this paper reflects on key elements that define the school and its science education programs as innovative and transformative.

Introduction

The genesis and development of the Australian Science and Mathematics School (ASMS) was an innovative opportunity, and an opportunity to be innovative.

Almost always, new schools are established and built because of the pragmatic need to service the general education requirements of a new population of students and almost always around a comprehensive neighbourhood schooling model. There was no such driver for the establishment of the ASMS, its origins being driven by the need to explore new ways of teaching and learning in science. An innovative opportunity was generated that continues to be pivotal in the generation of new ideas and new thinking.

The ASMS was never to be more of the same:

> Policymakers and educators in the western world, are gradually realizing that traditional schooling has run its course and that trying to improve it by a policy of 'more of the same', is senseless. Yoram Harpaz (2000)

Students, educators and leaders are all learners at the centre of re-thinking schooling at the ASMS. Their working premise is that quality science education is embedded in quality schooling and they are all striving for what can be better, different, creative and innovative.

Deep thinking and communicating about core beliefs concerning learning and schooling generated six big ideas as 'perspectives for the future' for the ASMS. What would the ASMS do and be? The Australian Science and Mathematics School would:

- Respond to the current and future interests and needs of its students to establish critical and transparent models of excellence in science and mathematics education
- Provide a learning environment of leading edge and enterprise-oriented science, mathematics and technology
- Provide a learning culture for its students that derives from the learning culture of its staff, which in turn derives from their interaction with university and industry scientists and educators
- Prepare young people to be creative, critical, informed and motivated contributors responding to professional, personal and social issues

- Increase participation and success of senior secondary students in science, mathematics and related technologies and transforms students' attitudes to science and mathematics as career paths
- Be an agency for change and enhancement of science and mathematics education for the state of South Australia and then nationally and internationally.

ASMS Cycle of Re-Thinking

The development of the ASMS has been driven by an adaptation of models commonly associated with terms such as 'learning organisations' and 'action research' (Argyris & Schon, 1996; Senge, 1990; Dibella, 2003). The ASMS Cycle of Re-Thinking (Figure 1) is a representation of the interaction of pivotal factors that are explicitly identified as core to the achievement of the outcomes associated with the starting 'big ideas'.

The ASMS views itself as a development and research school that engages in a continuous cycle of planning, acting, studying outcomes of action and reflecting collaboratively in order to develop new knowledge and levels of understanding. This in turn informs planning for subsequent action.

Re-thinking the science curriculum

The ASMS is attempting to better understand how to liberate science teaching from rigid preoccupations about what needs to be learned, in what sequence and when. It has responded by developing an interdisciplinary curriculum and a pedagogical approach for its Year 10 and 11 students that enables student-directed learning which is responsive to students' interests. It is a

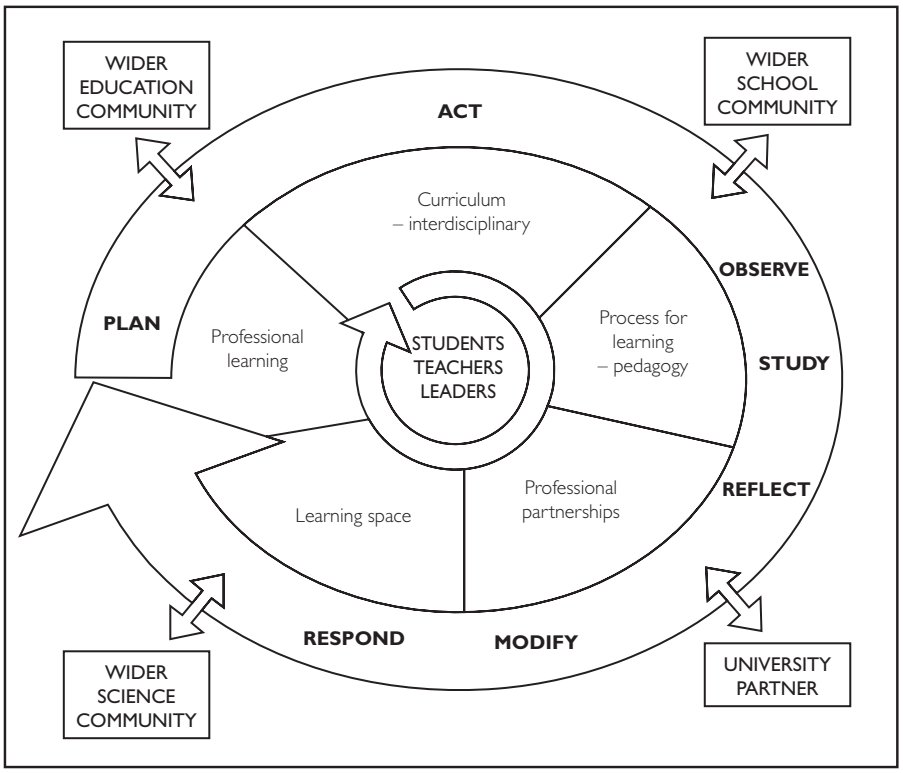

Figure 1 ASMS Cycle of Re-Thinking

curriculum designed to facilitate learning connections across the traditional disciplines and to give confidence that a depth of discipline knowledge and understanding will be gained.

The constructs that provide pathways into higher education are such that Year 12 students remain locked in the state-wide syllabuses describing the traditional disciplines of physics, chemistry and biology.

Learning is structured in Central Studies, around some key themes such as 'Towards Nanotechnology', 'Earth and Cosmos' or 'Sustainable Futures'. These themes liberate science from being seen as a set of narrow technicalities. The interdisciplinary studies are shaped by a curriculum framework (see Figure 2) designed to facilitate deep engagement with essential scientific knowledge, skills and attitudes across the key science disciplines and connect with projects of major significance that may involve university and workplace studies. Students and staff are weaving scientific understanding and logic into cultural, social, historical, legal and ethical perspectives, generating meaningful and connected understandings about the world for students.

The development of a science education program that engages students with opportunities for learning at the leading edge of enterprise-oriented science has been a significant priority. Predictably, students' future endeavour and their occupations will be aligned with these sciences and technologies. Re-shaping science curriculum for the inclusion of leading-edge science is a significant vehicle for extending the levels of student engagement in learning science. Traditional teaching and learning in schools does not speak to students about the science and technology of satellite navigation, biomimetics, laser tweezers, intelligent polymers, quantum

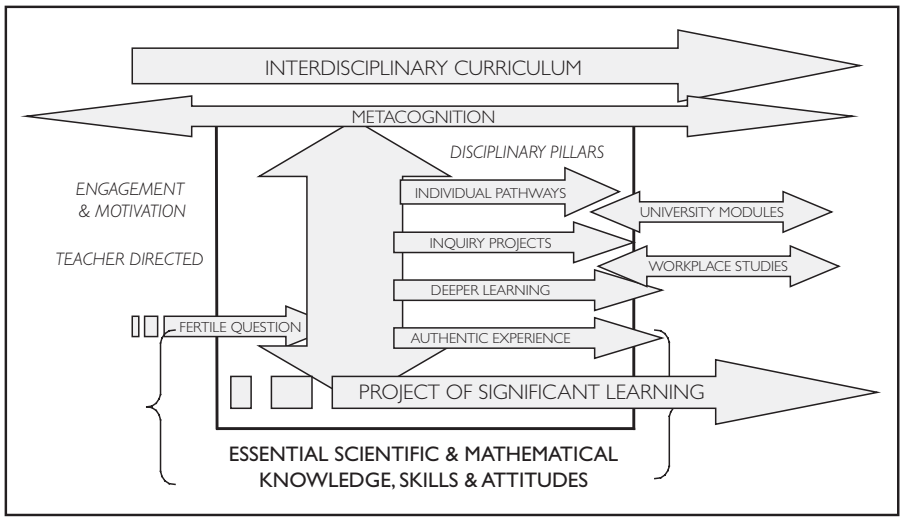

Figure 2 ASMS Central Study Framework

computers, artificial photosynthesis or other emergent technologies that will dramatically change our lives in the near future. A significant focus for curriculum development has been the search for the foundational science that shapes the 'disciplinary pillar' at the centre of each Central Study. Opportunities for learning and deep understanding of the emergent sciences emanate from the disciplinary pillar.

Through the development of 'University Modules', the ASMS has also developed an enrichment and extension curriculum that engages students with snapshots of leading-edge science. University academics tend to take the lead in 'University Modules' with teachers working alongside. The modules allow students to delve deeper into a scientific aspect connected to one of the Central Studies, with some elements finding their way into the core of the Central Studies, supporting further re-generation of curriculum.

The innovative curriculum at the ASMS has been generated from extensive consultation processes and redefines the traditional concept of curriculum in senior secondary education. The curriculum achieves a validity and depth endorsed by practising scientists and educators. The curriculum is ever evolving as new content and new pedagogical approaches to the teaching of this content emerge. An emergent curriculum, reflective of emergent science, is under development.

Re-thinking learning space

The design of the ASMS building moves away from architectural-pedagogical paradigms that reinforce teacher-centred pedagogical practice and define the traditional power relationship between teacher and student. It is designed for highly collaborative and interactive, student-directed approaches that transfer the power of adolescent social interaction into the learning environment. It allows for students to work independently, interacting in small groups or engaged in direct instruction in groups ranging in size from two to two hundred.

Flexibility and adaptability in the use of space, by both teachers and students, supports a wide variety of teaching and learning activities and styles. Teachers' work spaces are open areas. These merge with 'learning commons' and facilitate ready access by students throughout the school day. Open, multi-purpose 'studios', where students' primary activities are focused on scientific inquiry, have replaced conventional school laboratories where experimental replication has been the predominant point of engagement for students. Social space merges with physical learning space which, in turn, merges with e-learning space.

The fundamental idea of the ASMS is to be a collaborative learning community where the teacher's predominant role, defined as learning coach, mentor and 'guide on the side', is enhanced by this architecture. The developed concept of a collaborative learning community facilitates the aggregation of critical intellect that, in some ways, emulates that which is typically attributed to scientific research projects.

Re-thinking processes for learning

This architecture facilitates learning that draws on and transfers the power of adolescent social interaction into the learning activities. This fosters high levels of collaboration between students and among teachers and students. The talking, doing, watching and thinking that fosters and generates youthful exuberance and powerful learning in social constructs is applied and adapted to shape rigorous learning in the school.

Through adaptations of Harpaz's 'Community of Thinking' model, teachers at the ASMS are planning learning activities and developing the artefacts to support learning with the following predominant approaches:

- *Talking:* Open-mindedness and the ability to adapt to change is supported by simulations, teamwork, experimentation, ideas generation, problem solving, inquiry projects, discussion, analysis and argument in interactive settings.

- *Doing:* Students are actively engaged in experimentation and investigation assisting them to make connections between their learning and the real-life application of the learning. They are supported in practising and applying their learning and developing models for replication. They are challenged to get things done, to implement solutions and to discover what really works.
- *Watching:* Students are provided with the opportunity, time and space to observe and reflect on experiences. They are engaged in observing, listening, researching and reviewing with an emphasis on understanding ideas and situations from different perspectives. Students are challenged to see and develop different solutions to challenging, 'fertile' questions where objectivity and astute judgement is important.
- *Thinking:* Students are engaged in significant inquiry projects where they are formulating conceptualisations of situations in order to generate theories, models and conclusions that add to their understanding of the situation. Skills of critical analysis and creative thinking are highly valued and supported through the provision of explicit thinking time.

The teaching practice at the ASMS is variously summarised as being collaborative, inquiry-based, and student-centred, constructivist learning. It is applied in a comprehensive, interdisciplinary curriculum framework and is clearly focused on supporting students to think independently and critically and to gain a deep understanding of concepts, in particular around science.

Re-thinking professional partnerships and processes for professional learning

The ASMS is a place where students, teachers, university scientists, parents and community members mutually connect, contextualise and engage in the learning. The provision of a learning culture for its students that derives from the learning culture of its staff has been a pervasive and enduring intent.

The development of a strong partnership with Flinders University has been an integral component supporting the re-thinking. Opportunities for teachers of science to focus on developments in scientific knowledge and methods have come through co-construction of science education programs by teachers and research scientists. Teachers and scientists have worked side by side on the development of curriculum and laboratory activities, on reading and analysing current scientific writings and through participation in science research conferences.

Reflecting on the re-thinking

An innovative, inviting and engaging school culture has been created. It is heard in the voices in the school's buildings; the teacher's voice which is confirming, encouraging, acknowledging and challenging; the student's voice which is excited, confident, inquisitive, sharing and launching into other places. It is generated through exciting curriculum and interdisciplinary teaching where the focus is on connected, student-driven learning and not the confines of traditional subjects. A commonplace activity in the ASMS is telling and listening about learning, and especially learning about learning.

The foundation beliefs on which the ASMS is staking its future are really important for all in the school community. These are being continually worked through and explicitly articulated. A shared sense and awareness is emerging of what it is that drives and supports the behaviours, actions and ethics of the school. You can see people working in sync with each other. There is an awareness of what is happening elsewhere in the school and why. The foundations are in place that allow for a relentless focus on learning, in particular in innovative science. Students are increasingly articulate about their learning, the degree of rigour in the curriculum, their level of engagement with the learning activities, the quality of the relationships in the school community, their learning outcomes and myriad other indicators of importance to their lives. Their benchmarks are the most important of all and attentiveness to these voices will drive future innovative practice.

Reflection is a constant within the ASMS Cycle of Re-Thinking. What our students feel, say and do is of primary interest and importance. Student opinion about their schooling has been collected through the use of the ACER: School Life Questionnaire (see Table 1).

The students' opinions about their schooling experiences provide general support for the directions taken in the re-thinking within the development of the ASMS. The high levels of agreement expressed by students in relation to their feelings about their social integration at the school are consistent with the significant focus on collaborative learning and the sense of a positive community culture that prevails in the school.

The intention to move away from architectural-pedagogical paradigms that reinforce teacher-centred pedagogical practice and define the traditional power relationship between teacher and student is supported by the students'

Table 1 Student Opinion: ACER: School Life Questionnaire (2005 ASMS cohort)

Percentage Agreement								
	Year 10		Year 11		Year 12		All	
	2004	2005	2004	2005	2004	2005	2004	2005
General satisfaction	71	78	80	69	67	69	73	72
Teacher items	87	85	83	78	85	83	85	82
Relevance items	86	76	84	74	75	76	82	76
Success items	81	74	86	78	68	75	79	76
Status items	69	70	73	72	71	70	71	71
Social integration items	88	88	88	86	91	88	89	87
Negative affect items	18	23	19	21	32	29	23	25

affirmation of their level of satisfaction with teachers and the teaching that they receive. With this context in mind, it is also useful to note the increase in 'negative affect' alongside the decreasing agreement in 'general satisfaction' as students move into their final year of schooling and are faced with state-determined syllabuses and high stakes examinations where students have significantly less opportunity to negotiate and direct their learning.

The learning outcomes of the first cohort of students to complete their final three years of schooling at the ASMS are also reaffirming. These students came to the ASMS from a diversity of backgrounds, from over 40 different feeder schools, from all areas of South Australia, from a range of socioeconomic backgrounds and from a range of cultural backgrounds. Their interest in science, not their ability in science, was used as a criterion for enrolment. Using South Australian Certificate of Education school exit measures, this cohort achieved well above the means for all students in South Australia. Thirty-two per cent of the ASMS students were in the 90th percentile and 52 per cent achieved results that put them in the top 20 per cent of students in the state.

Such outcomes are welcome data as the ASMS moves forward in its quest to re-think schooling for students in the senior secondary years. However, the leaders and staff of the ASMS along with their University colleagues recognise there are still many factors to re-think including the tracking of graduates from the ASMS to see if careers in science and mathematics are pursued; the challenge of providing interdisciplinary and personalised learning while state-based examinations still assess on a discipline specific basis; and attracting appropriately qualified staff ready to work in innovative ways. The re-thinking continues.

References

Argyris, C. & Schon, D. A. (1996), *Organisational Learning II: Theory, Method and Practice*, Addison-Wesley, Reading: MA.

Australian Council of Educational Research (2005). *Reforming the teaching of science and mathematics through the collaboration of Flinders University staff in the Australian Science and Mathematics School: New science foundations project*. Melbourne: ACER.

Australian Government (2004). *Australian science: Building our future*.

DEMOS (2004). 'About Learning: Report of the Learning Working Group' www.demos.co.uk

Dibella, A. J. (2003). Managing organisations as learning portfolios, *The Systems Thinker*, Vol. 14, No. 6.

Harpaz, Y. (2000). *Teaching and learning in a community of thinking*. Jerusalem: Branco Weiss Institute.

Senge, P. (1990), *The fifth discipline*, Doubleday, New York, NY